# Waveguide Coupler Monitors and RF Interlock Detector Cable Distribution and Attenuation

Jim Steimel

01/08/07

Version 1.0

## Introduction

This document illustrates the purpose of the different diagnostics couplers in the waveguide distribution system of the HINS test facility at Meson. It also describes the signal cabling and justifies the signal attenuation levels based on the maximum safe operating conditions and the RF interlock system maximum input levels.

## Coupler Distribution

There are six different diagnostic directional couplers in the HINS test facility at Meson. Each coupler has a coupling factor of 60dB. One coupler measures the forward and reflected power directly out of/in to the klystron. Another coupler measures the forward and reflected power coming out of/in to the main circulator. Another coupler measures the forward and reflected power going in to/out of the waveguide load that will eventually be replaced by the beam line waveguide distribution. Two more couplers measure the forward and reflected power at the upstream and downstream end of the waveguide shutter. Two other couplers measure the forward and reflected power in the 250kW and 25kW coaxial lines for the cryostat test cave. All of the coupler signals are cabled back to a single rack for monitoring and detecting.

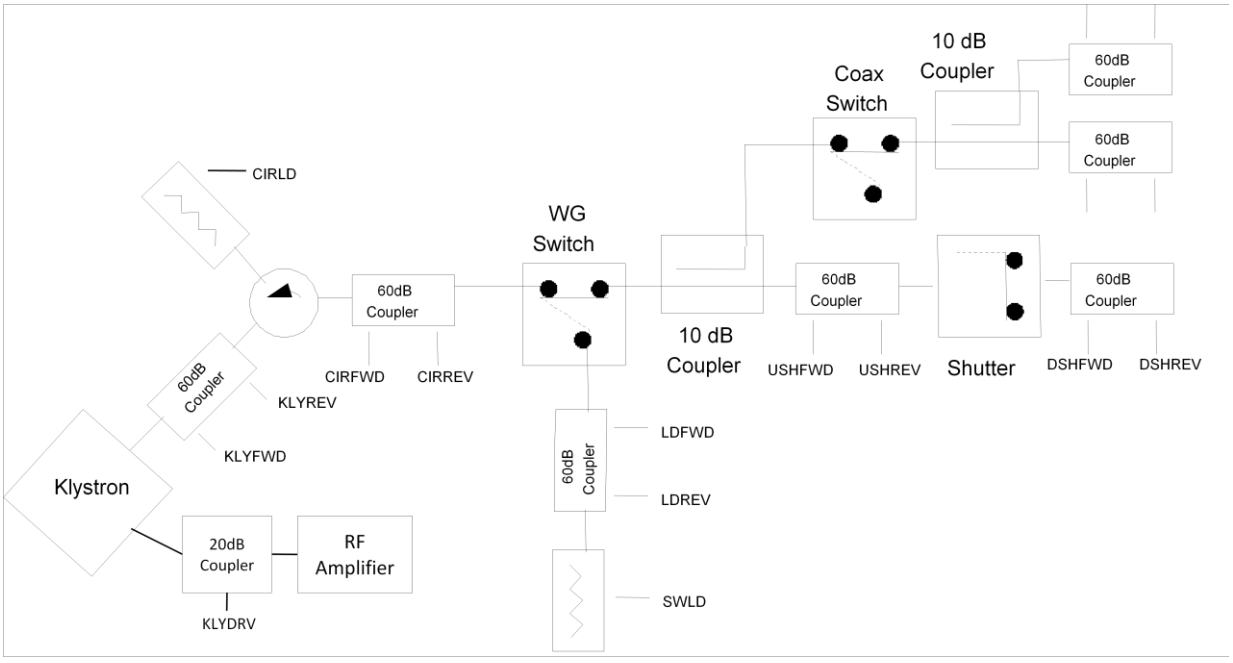


*Figure 1: Block Diagram of the RF power distribution and the diagnostic signals.*

## Monitors and Detectors

The coupler signals are routed and split for two different locations. One location is the front panel of the rack where the raw signal can be measured on a scope or other analyzer. Where possible, the signal is attenuated to provide a 2V peak amplitude at the maximum coupler output level. The other location is a RF detector that is used to disable the klystron RF if signals exceed specified values. The maximum signal the detectors can handle is -5dBm. The coupler outputs are attenuated so that the maximum coupler output levels are below this level.

## Maximum Coupler Power Levels

This section justifies the expected maximum power levels for each direction of the diagnostic couplers.

### *Full Power Couplers*

There are a number of coupler ports that must be capable of handling the full 2.5 MW of the klystron. These couplers are: the klystron forward power, the circulator forward power, the load (beam line) forward power, and the forward and reflected ports of the upstream shutter coupler. The upstream shutter coupler sees the full power in both directions when power is directed to the test cave.

### *Test Cage Power Levels*

The test cage will only require a maximum of 650kW of power to test a full RFQ IQ-modulator. It is possible to get 100% reflection from the test components back to the klystron. The couplers that need to handle this power level are the forward and reflected ports of the downstream shutter coupler and the reflected signal port of the circulator. This is the largest amount of reflected power we would expect to come back to the circulator from any part of the RF distribution.

### *Test Cave Couplers*

The test cave couplers monitor the 250kW and 25kW lines that enter the cavity test cave. Each line must be capable of handling it's full specified power and full reflection from its load. The forward and reflected ports of the 250kW coupler must handle 250kW max, and the ports of the 25kW coupler must handle 25kW max.

### *Low Reflection Ports*

Two of the coupler ports should see very little reflection during operation. The klystron coupler should see little power on its reflected port due to the circulator protecting it. The limit on this port is set to 25kW to insure less than 20dB of insertion loss into the waveguide and circulator. The circulator is specified to be better than 30dB of directivity, so more than 20dB of reflection points to a fault in the circulator or load. The second coupler with little reflection is the load coupler. The load reflection is specified to better that 26dB. The limit on this port is set to 25kW also, to insure better than 20dB of reflection from the load. This should also be consistent with the beam line distribution as well since all beam line tuners will be equipped with there own circulators that should have reflection and directivity better than 20dB.

## Summary

The following table summarizes the power limits on the different couplers and calculates the attenuation required to meet the operating limits of the monitors and detectors. Notice that some of the attenuation values are negative numbers because there isn't enough available power from the couplers

to meet the 2V peak requirement. These signals will not be attenuated and set for maximum power when at 1V peak.

*Table 1: Summary of coupler signal levels and attenuation settings. Labels are the names of the actual cables pulled.*

| Signal Description | Signal Label | Max Power (MW) | Cable Attenuation (dB) | Splitter Attenuation (dB) | Attenuation for Monitor (dB) | Attenuation for Detector (dB) | Measured Total Attenuation for Monitor (dB) |
|---|---|---|---|---|---|---|---|
| Klystron Fwd Power | KLYFWD | 2.500 | 0.39 | 3 | 14.5688002 | 35.5894001 | 19.13 |
| Klystron Refl Power | KLYREV | 0.025 | 0.39 | 3 | -5.43119983 | 15.5894001 | 4.1 |
| Circulator Fwd Power | CIRFWD | 2.500 | 0.48 | 3 | 14.4788002 | 35.4994001 | 19.16 |
| Circulator Refl Power | CIRREV | 2.500 | 0.48 | 3 | 14.4788002 | 35.4994001 | 19.16 |
| Circulator Load Power | CIRLD | 2.500 | 0.48 | 0 | 17.4788002 | N/A | |
| Beam Line RF Fwd Power | LDFWD | 2.500 | 0.38 | 3 | 14.5788002 | 35.5994001 | 18.99 |
| Beam Line RF Refl Power | LDREV | 0.025 | 0.38 | 3 | -5.42119983 | 15.5994001 | 4.07 |
| Waveguide Switch Load | SWLD | 2.500 | 0.38 | 0 | 17.5788002 | N/A | |
| Upstream Shutter Fwd Power | USHFWD | 2.500 | 0.59 | 0 | 17.3688002 | N/A | 17.92 |
| Upstream Shutter Refl Power | USHREV | 2.500 | 0.59 | 0 | 17.3688002 | N/A | 17.93 |
| Downstream Shutter Fwd Power | DSHFWD | 0.650 | 0.6 | 3 | 8.50853365 | 29.5291336 | 13.35 |
| Downstream Shutter Refl Power | DSHREV | 0.650 | 0.59 | 3 | 8.51853365 | 29.5391336 | 13.25 |
| 250kW Fwd Power | | 0.250 | 0.6 | 3 | 4.35880017 | 25.3794001 | |
| 250kW Refl Power | | 0.250 | 0.6 | 3 | 4.35880017 | 25.3794001 | |
| 25kW Fwd Power | | 0.025 | 0.6 | 3 | -5.64119983 | 15.3794001 | |
| 25kW Refl Power | | 0.025 | 0.6 | 3 | -5.64119983 | 15.3794001 | |
| Klystron RF Driver Power | KLYDRV | 40.000 W | 0.3 | 0 | 9.7 | N/A | |